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Title: Impacts of Coordination with Supplier and Customer on Quality and Flexibility Performance

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1. Introduction

A supply chain is a network of firms involved in different processes and complex activities such as planning, design, distribution, selling, support, usage and recycling of the product through upstream and downstream linkages, to produce value in the form of products and services delivered to ultimate customers (Arshinder *et al.* 2008). These firms pursue different goals, often to detriment of one another. However, recent research has suggested that supply chain performance depends on how well supply chain partners work together and not on how well each

partner performs individually. In this common-goal view, the interdependent activities between supply chain members need to be coordinated to achieve the best fit among supply chain partners. It has been shown that poor coordination among supply chain members has negative consequences on performance, such as inaccurate forecasts, low capacity utilization, excessive inventory, inadequate customer service, inventory turns, inventory costs, time to market, order fulfillment response, quality, customer focus and customer satisfaction (Ramdas and Spekman 2000).

Similarly, Fine (1998) argues that product design, process design and supply chain design decisions have to be integrated to support one another in order for firms to stay competitive. Internal integration facilitated through information sharing and computer technology leads to improved product performance. At the same time, internal constituents seek to integrate with customers and suppliers in order to get information necessary to reduce uncertainty and ultimately, enhance performance. The logic that drives internal integration is equally relevant for integrating activities of external entities (Koufteros *et al.* 2005). It is, thus, clear that a firm needs to develop effective coordination within and beyond its boundaries in order to maximize the potential for converting competitive advantage into profitability (Dyer and Singh 1998). Several studies (Lee *et al.* 1997, Metters 1997, Narasimhan and Jayaram 1998, Johnson 1999, Frohlich and Westbrook 2001, Stank *et al.* 2001, Vickery *et al.* 2003) have shown that firm coordination has a positive impact on performance. Wal-Mart, for instance, shares sales and inventory information with its key suppliers. This practice allows the retailer to quickly replenish stores shelves or, by contrary, to discontinue carrying slow moving items (Houglund 2007). Also, Nike successfully coordinates its designing and marketing capabilities with manufacturing capabilities of its suppliers in Asia, thereby benefiting from flexibility in keeping up with changing footwear requirements of customers (Jones 2007).

Given the nature of interdependence between supply chain members, coordination is a necessary prerequisite to integrating operations so as to achieve the mutual goal of the supply chain as a whole as well as those of its units (Simatupang *et al.* 2002). Thus, coordination mechanisms, which are tools for managing these interdependencies, are instrumental in eliminating supply chain sub-optimization and achieving desirable performance outcomes (Fugate *et al.* 2006). For instance, supplier coordination is critical given that purchasing represents around 50% of the cost of goods sold by US manufacturers. Moreover, suppliers have a great impact on cost, quality, technology, speed and responsiveness of buying firms (Ragatz *et al.* 2002). On the other hand, customer coordination, another coordination mechanism, ensures that the voice of customer is embedded in the product development effort, thus boosting the firm's product innovation and quality performance (Koufteros *et al.* 2005).

In this paper, we investigate the direct impact of supplier and customer coordination on quality and flexibility performance. Among the various dimensions of performance, we focus on flexibility and quality performance as these are critical in today's demanding and fast changing environment. We thus seek to offer a different perspective on the relationship between supplier and customer coordination, and performance than the extant literature, which also benefits practitioners. Also, based on a literature review on supplier and customer coordination from a contingency perspective, we investigate the contingency influence of two important variables of firm size and clockspeed on the coordination to performance relationships. Specifically, we seek to understand how firm size and clockspeed moderate the influence of supplier and customer coordination on quality and flexibility performance.

The flow of this paper is that we use extant theories of coordination and contingency to formulate our conceptual model. The related hypotheses and research design and methodology are discussed next, followed by the statistical analysis and discussion sections.

2. Literature review

The importance of coordination on organizational goals was recognized early in organization theory by Barnard (1938), who argued that “when ends have been adopted, the coordination of acts as means to these ends is in itself an essentially logical process” (Barnard 1938, p. 186). Often, however, good coordination is almost invisible and is mostly noticed when it is lacking. Malone and Crowston (1994) define coordination as the process of managing dependencies among activities. Although there have been several perspectives from which the problem of coordination has been researched, they all share the idea of interdependence as a prerequisite to coordination, since without interdependence there is nothing to coordinate (Malone and Crowston 1994). However, coordination problems arise from dependencies that constrain how tasks can be performed, and additional activities - coordination mechanisms - must be carried out in order to overcome these problems (Crowston 1997).

2.1 Theoretical Background on Coordination Theory

The interdependent activities that are performed by different actors in a supply chain to achieve goals may require acquisition or creation of different resources (Crowston 1997). There are three types of coordination: coordination between two tasks, coordination between two resources, and coordination between a task and a resource (Crowston 1997). The type of coordination used in the organization is a function of the extent to which the situation is standardized: coordination by plan is based on pre-established schedules, whereas coordination by feedback involves transmission of new information (March and Simon 1958). The type of organization structure, centralized versus decentralized also facilitates the coordinated action of interdependent elements (Thompson 1967). The concept of task interdependence is the extent to which the relationship between groups could be categorized into one of the three patterns of workflow that exist between them, namely pooled, sequential and reciprocal. As such, the coordination mechanisms

corresponding to these types of interdependence have been identified as being standardization of rules, planning and scheduling, and mutual adjustment (Thompson 1967). Van de Ven *et al.* (1976) added the fourth type of interdependence, the work unit of a team, and proposed that uncertainty and team size are additional determinants of coordination. They also claim that as interdependence level increases, the need for group coordination also increases. To accommodate the different types and levels of interdependence between functions, two distinct aspects of coordination, namely the amount of interdependence and the amount of conflict between functions, were proposed by Victor and Blackburn (1987).

Thompson's (1967) typology was extended by Malone and Crowston (1994) who suggested different kinds of dependencies, such as shared resources, producer/consumer relationship, simultaneity and task/subtask, and corresponding coordination mechanisms that can be used to manage them. The effectiveness of coordination mechanisms depends on a shared view of coordination structure because it facilitates the visibility of the interconnections between assignment of individual responsibilities and their interrelationships to achieve some organizational objectives (Bailetti *et al.* 1994). More specifically, Adler (1995) argued that, since the objective of coordinating design and manufacturing departments is to ensure an acceptable fit between product design and manufacturing process parameters, the most efficient interdepartmental coordination mechanism is that which is able to deal with the uncertainty of this product/process fit at least cost to the organization. In this paper, we take this argument to the interfirm level since the interdependencies also arise between firms, e.g. between a buyer and its suppliers. Thus, coordination becomes an even critical issue as there is typically more than a single governing authority within a supply chain that establishes the best coordination mechanism among supply chain partners in order to achieve their mutual goals.

2.2 A Contingency Approach to Supplier and Customer coordination

While the literature on supply chain integration has offered several types of coordination, such as customer/market coordination, information coordination, logistics and distribution coordination, supplier coordination, and purchasing coordination (Das *et al.* 2006), our focus in this paper is on supplier and customer coordination. Lately, research has shown that effective supplier coordination is a key factor for manufacturers to remain competitive in today's global competition. Purchased materials represent around 50% of the cost of goods sold in manufacturing industries worldwide, with a likelihood of percentage increase as the volume of outsourced work continues to increase. Thus, supplier coordination is a critical factor for improving performance in terms of costs, speed and product quality. Through supplier involvement, the unique capabilities that allow a firm to build a competitive advantage are complemented and enhanced.

Consistent with Frohlich and Westbrook's question (2001) of whether it is more important to link with suppliers, or link with customers or link with both, we are also interested in studying customer coordination as well as supplier coordination. It is well-known that customer integration involves determining customer requirements and tailoring internal activities to meet these requirements (Koufteros *et al.* 2005). Moreover, early customer integration leads to a stronger relationship with the partner, a better understanding of market needs, fewer errors in the early development process and a better product quality (Enkel *et al.* 2005).

The contingency theory tries to understand organizational issues from a contextual perspective. Applying this framework to our research objective, it means that determining how supplier and customer coordination impacts performance needs an analysis of the specific contexts. The extant work that has been conducted with respect to supplier and customer coordination is summarized in Tables 1a and 1b. A brief summary of these works follows.

Insert Tables 1a and 1b about here

Ragatz *et al.* (2002) studied the effect of elements of the supplier integration process on cost, quality, and new product development (NPD) time, under conditions of technology uncertainty. Their findings suggested that technology uncertainty has a negative impact on cost results, but no direct effect on quality or cycle time. Also, Petersen *et al.* (2003) found prior knowledge of the supplier, sharing of technology and cost information, and supplier involvement in decision making as influential factors on project success. Their results indicated that the performance outcome problems associated with technology uncertainty can be mitigated by greater use of technology sharing and direct supplier participation on the NPD team. Furthermore, Petersen *et al.* (2003) concluded that there is no one best method to integrate suppliers into NPD, and the level of technology uncertainty present determines the relative moment when the supplier should become involved.

Using data from global organizations, Petersen *et al.* (2005) found support for the value of early supplier involvement in the NPD process. More specifically, they identified supplier involvement timing and level of supplier's design responsibility as moderating factors of the relationship between early supplier involvement and product design performance or financial performance. Also, Parker *et al.* (2008) proposed a model that explores the appropriate timing and level of integration with suppliers in NPD projects employed by international organizations in various industries. The contingencies analyzed in this study include technological newness, buyer-supplier relationship and strategic importance of the supplied item. The positive relationship found between the extent of integration and perceived project performance needs to be interpreted in the broader context of the model, namely the tight integration of allied strategic suppliers that provide new technologies most often results in higher perceived performance.

Lakemond *et al.* (2006) examined practices of interorganizational coordination of supplier involvement in six product development projects performed at the Swedish packaging company Tetra Brik, a world leader in paper-based solutions in the food industry. Project integration coordination, direct ad hoc coordination, and disconnected sub-project coordination are the three general types of coordination distinguished in this case study. However, given that the three mechanisms are suitable under different conditions, Lakemond *et al.* (2006) identified the need for a fine-tune approach to supplier involvement in product development, based on an analysis of relevant contingency factors, such as the degree of task dependency, diverging expectations, and the presence of long-term intentions. In another case study (of eight NPD projects in four buying firms based in Netherlands in different industries), Van Echtelt *et al.* (2007) found that successful supplier involvement is dependent on the coordinated design, execution and evaluation of strategic long-term processes and operational short-term management processes, and the presence of enabling factors such as a cross-functional oriented organization. Moreover, the required intensity of these processes and enablers depends on contingencies such as firm size and environmental uncertainty.

Devaraj *et al.* (2007) found a positive impact of supplier integration on cost, quality, flexibility and delivery performance, and no direct benefit of eBusiness technologies on performance in manufacturing firms. However, Devaraj *et al.* (2007) claimed an indirect relationship between eBusiness technologies and supplier integration that leads to better performance, since these technologies support supplier integration.

Using data collected from 244 manufacturing firms in various industries, Koufteros *et al.* (2005) investigated whether contextual variables such as uncertainty, equivocality and platform development strategy moderate the relationships between integration strategy (internal and external) and performance. Their findings indicated that both internal and external integration

positively influence product innovation and quality, and thus profitability, with equivocality as a moderating factor. Also, Koufteros *et al.* (2007) examined the antecedents and consequences of supplier integration in product development activities. They found that, between the black-box integration (wherein the development of components for the customers is carried out by suppliers on their own) and gray-box integration (wherein suppliers work alongside the customer's engineers for product development), only gray-box integration shows a positive relationship with product innovation. The results of this study partially supported the moderating impact of firm size.

Recently, Jayaram (2008) tested the multidimensional nature of supplier involvement in NPD projects in high-tech industries firms, and found it as comprising of communication and information sharing, design involvement, and infrastructure, all of which having a positive impact on the project performance, operationalized in this study as product cost, conformance quality, design quality and time-to-market. While the firm size was not found a significant moderator, the study found support for the contingent influence of market stability on the relationship between supplier involvement and NPD project performance.

In conclusion, the extant literature on supplier coordination has revealed the prevalence of studies which have focused on NPD projects, as involving suppliers in NPD is critical in an ever-increasing competitive environment due to the expected positive effect on development time, product cost and product quality. Although not always empirically tested, the contingency factors have ranged from uncertainty (operationalized as environmental or technological), market stability, equivocality, platform development strategy, degree of task dependency, degree of diverging expectations, buyer-supplier relationship, long-term collaboration objectives, stage of integration, supplier's level of responsibility, strategic importance of the supplied item, to firm size. The fact that the firm size does not have an influence on the relationship between

coordination and performance could be noticed, although one study (Devaraj *et al.* 2007) claimed that its results are more reflective of small to medium firms which formed 73% of the sample.

To our knowledge, there has been little research related to the contextual factors affecting the impact of customer integration on performance. One study (Souder *et al.* 1998) examined the impact of R&D/customer integration on NPD effectiveness operationalized as NPD cycle time, prototype development proficiency, design change frequency, R&D technical effectiveness, R&D commercialization effectiveness, product launch proficiency and market forecast accuracy. Based on 101 NPD projects at high-tech firms in the US and the UK, the results of the study indicated that R&D/customer integration has an impact on cycle time, R&D technical effectiveness and R&D commercialization effectiveness. Whereas both technical and market uncertainty have a moderating effect on design change frequency, market uncertainty only moderates market forecast accuracy.

Another study (Koufteros *et al.* 2005) investigated whether contextual variables such as uncertainty, equivocality and platform development strategy moderate the relationships between integration strategy (internal and external) and performance in various manufacturing industries. The findings indicated that customer integration has an indirect impact on quality through the effects on product innovation, especially in high equivocality environments. On the other hand, Devaraj *et al.* (2007) found that customer integration, as measured by specific information flows and collaborative efforts with customers, does not by itself relate to performance. That is, customer integration by itself does not directly affect operational performance and must be implemented with supplier integration to realize its full potential.

Based on our literature review, it appears that there is still research need to identify the specific conditions under which both supplier coordination and customer coordination in

manufacturing firms are effective. Hence, we propose investigating to what extent supplier coordination as well as customer coordination influence flexibility performance and quality performance, as shown in Figure 1:

Insert Figure 1 about here

3. The Context of China

China provides a unique setting for our research objective. With its low-cost labor resources, large economies of scale and low domestic-sourcing costs, China has emerged as the workshop of the world. The country's cost advantage is reflected in each stage of the supply chain, from purchasing to manufacturing, logistics, warehousing, storage and sales. This is also due to the large number of supply clusters that cover basically every major product category. The geographic proximity of the firms within clusters facilitates supply chain coordination, as firms can be more responsive and effective in managing their supply chains. For instance, the flexibility of facilities and the capacity aggregation allow for better handling of uncertain demand and supply disruptions. The large volumes of purchased goods and shipments of finished goods can provide significant inbound and outbound transportation costs savings. The shipping costs and flow of inventories between suppliers and manufacturers within the supply cluster also benefit from to the geographic closeness of the firms. The sharing of information is facilitated by face-to-face meetings which lead to developing personal relationships and community ties, very important in Chinese business culture.

The proximity to suppliers can be a factor for which some manufacturers may choose to not do business in China. That was the case of Sony Corp., which in 2002 shifted production of its high-tech digital cameras and camcorders back to Japan, closer to its suppliers of special high-

tech parts. Since the cycle time is positively associated with supply chain flexibility and responsiveness to market changes, Sony considered minimizing the cycle time of its high-end products more critical than minimizing manufacturing costs (Jiang 2003).

Also, international car manufacturers that established facilities in China unexpectedly found that the cost of purchased goods in China can even exceed the cost in traditional markets due to lower volumes. Labor experience, poor infrastructure, higher communication costs and second-class machinery or processes could lead to inefficient production and, thus, higher costs (Hedderich *et al.* 2005). Therefore, manufacturing industry in China is an interesting research setting to gain insights about supply chain coordination and its impact on flexibility and quality performance.

4. Research Hypotheses

The contingency theory addresses the following question: “Are there any universally beneficial practices or are there only contextually appropriate practices?” (Peteraf and Reed 2007, p. 1090). In this study, we follow contingency theory by submitting the same question, “Are supplier coordination and customer coordination always beneficial to firm performance, or are there contextual factors that contribute to improved performance?” In other words, we investigate whether the fit between supplier coordination and customer coordination on performance on the one hand, and the moderating influence of firm size and clockspeed on these relationships on the other hand, matters or not.

In today’s highly competitive environment customers demand faster response and a wider variety of products, whereas competitors achieve performance levels higher than ever. In order to cope with this environment’s constraints, a firm needs to coordinate with its suppliers and customers due to the interdependencies among them. Supplier coordination can be viewed as a

state of synchronization among the supplier, purchasing and manufacturing constituents of an organization (Das *et. al* 2006). On the other hand, customer integration ensures that internal activities meet customer requirements (Koufteros *et al.* 2005). Both types of coordination are necessary to achieve high performance. Among the performance measures, flexibility is viewed as a solution. A firm's flexibility reflects its ability to effectively respond to market changes, and can be characterized by three dimensions. First, product flexibility is the ability to handle difficult, nonstandard orders, to meet special customer specifications, and to produce products characterized by numerous features, options, sizes, and colors (Vickery *et al.* 1997). Second, volume flexibility is the ability to effectively increase or decrease production in response to customer demands, which require close coordination between a manufacturer and its suppliers, especially when the demand is increasing. However, neither product nor volume flexibility can be effective without the flexibility of the physical processes employed for product manufacturing. We thus predict that:

H₁: Supplier coordination is directly and positively related to flexibility performance.

H₂: Customer coordination is directly and positively related to flexibility performance.

Large firms are associated with more resources than small firms. The fact that they can dedicate more resources to integrate their suppliers gives them more leverage in managing these relationships toward increased performance. On the other hand, small firms, due to lower budgets and fewer personnel, might seek more actively to integrate their suppliers and benefit from tight supplier integration. Whether large firms integrate their suppliers to a higher degree than small firms is not well-established. We therefore posit that:

H_{3a}: The interaction between supplier coordination and firm size is directly and positively related to flexibility performance.

H_{4a}: The interaction between customer coordination and firm size is directly and positively related to flexibility performance.

In today's environment, the ability to shorten the time between order placement and order delivery can confer an important advantage as the firm can more quickly react to market conditions. The buying firm needs, in turn, a quick reaction from its suppliers, in order to satisfy its customers. We therefore predict that:

H_{3b}: The interaction between supplier coordination and clockspeed is directly and positively related to flexibility performance.

H_{4b}: The interaction between customer coordination and clockspeed is directly and positively related to flexibility performance.

H₅: Supplier coordination is directly and positively related to quality performance.

H₆: Customer coordination is directly and positively related to quality performance.

H_{7a}: The interaction between supplier coordination and firm size is directly and positively related to quality performance.

H_{8a}: The interaction between customer coordination and firm size is directly and positively related to quality performance.

H_{7b}: The interaction between supplier coordination and clockspeed is directly and positively related to quality performance.

H_{8b}: The interaction between customer coordination and clockspeed is directly and positively related to quality performance.

5. Research Design and Methodology

5.1 Survey Design and Pretest

We first developed and administered a survey in a small number of US firms and used the results to revise the English version of the survey. The development of the survey and the sampling

procedures followed Dillman (2000) and Churchill (1979). Seven-point Likert scales were used to measure survey responses. A pretest was conducted before the questionnaire was finalized to reduce measurement error (Churchill 1979). The survey was then translated into Chinese and pre-tested with a group of 20 MBA students and 10 managers participating in the executive program with related-manufacturing work experiences. Their opinions and feedback were used to revise and finalize the questionnaire design, which was then back-translated into English to ensure the original meanings of the English version are maintained.

5.2 Survey Approach and Sample

A quality management association consisting of 2000 firms in manufacturing industries provided us a mailing list of 400 randomly selected manufacturing-related companies in the local area. The questionnaires along with postage-paid return envelopes were mailed to production/operations managers in these companies as identified in the membership list. After two weeks, 146 responses were received (within-city mails are usually received within 1-2 days). Then the research team sent out a second mailing to the remaining “non-respondents” and received additional 51 completed surveys. This led to a total 197 completed surveys, representing a very encouraging response rate of about 49.25%.

In order to test for the presence of non-response bias, comparisons were made between survey answers from early and late respondents (e.g., those that responded after the second mailing was sent out) (Armstrong and Overton 1977). A multivariate t-test yielded no significant mean difference between the early and late respondents at the 0.05 significance level. This suggests the non-response bias is probably not present in this study.

5.3 Questionnaire and Variables Measurement

Consistent with previous studies (Ward et al., 1996; Vickery et al, 2003; Shah and Ward, 2003), we used perceptual measures of operational performance. Scholars suggest that perceptual

measures of performance should be used when firms may be unwilling or unable to provide objective financial measures. Areas of a firm's operational strategy such as supplier coordination or customer coordination are often integrative in nature and also measured by multi-item scale.

5.3.1 Dependent variables: flexibility performance and quality performance

In the questionnaire, the respondents were asked to "rate your factory's performance, relative to its major competitors with respect to (1) product flexibility, (2) volume flexibility, (3) process flexibility, (4) product reliability, (5) product durability, and (6) quality (conformance to specifications)". These items were measured on 7-point Likert scales with 1="poor" to 7="excellent". The averages of the first three and the next three items above were used to measure flexibility performance (Cronbach's $\alpha=0.7237$) and quality performance (Cronbach's $\alpha=0.8863$) respectively.

5.3.2 Independent variables: supplier coordination and customer coordination

For the supplier coordination construct, respondents were asked to "indicate the degree of agreement to the following statements about quality goals with respect to any one factory or plant that your unit has responsibility". In particular, supplier coordination is measured by the average response score in (1) "we strive to establish long-term relationships with suppliers", (2) "quality is our number one criterion in selecting suppliers", and (3) "we rely on a small number of high-quality suppliers" (Cronbach's $\alpha=0.7671$). Customer coordination is measured by the average response score in (1) "we frequently are in close contact with our customers", (2) "our customers OFTEN visit our plant" (reverse-coded as "SELDOM visit" in the actual questionnaire), and (3) "our customers give us feedback on quality and delivery performance" (Cronbach's $\alpha=0.6242$). These items were measured on 7-point Likert scales with 1="strongly disagree" to 7="strongly agree".

Note that all dependent and independent variables displayed composite reliability values (Fornell and Larcker 1981) in excess of the 0.60 minimum for exploratory studies (Van de Ven and Ferry 1978, Churchill 1979, Flynn *et al.* 1990).

5.3.3 Control/Contingency variables: Firm size and Clockspeed

Two objective measures were used to control for performance effects. As in most other studies, firm size may delineate the difference in firm performance. Firm size was measured by the annual sales revenue (for the most recent year) for the factory concerned. The natural logarithm of it is used as the measure of firm size here as commonly adopted.

Another control variable, order cycle time - “how long (in days) does it take to complete a typical unit of your primary finished product, from date of customer order to date of customer shipment” – is an important supply chain parameter that all parties involved are concerned about. Its natural logarithm is used to represent the clockspeed.

All dependent, independent and control variables are standardized (subtracted from the mean and then divided by the standard deviation of the original) before interaction terms between independent and control variables are created, as suggested in Aiken and West (1991, p. 28-47). These ease the interpretation of results substantially. Table 2 and 3 present the summary statistics and correlation matrix of the original variables.

Insert Tables 2 and 3 about here

6. Statistical analysis

The hypotheses associated with the model presented in Figure 1 were tested using multiple regression procedure with contingency effects (see, for instance, Aiken and West 1991). The results for the flexibility performance equation are presented in Table 4, while those for quality

performance equation are presented in Table 5. Overall our model results are highly significant, as indicated by the R-square values and F-statistics in both equations.

Insert Tables 4 and 5 about here

In order to test our hypotheses, a hierarchical regression approach is adopted to examine the importance of each of the independent variables and control variables (Tabachnick and Fidell 1996). First, the independent variables representing supplier coordination and customer coordination are entered (see first column labeled Model 1 in Tables 4 and 5). Then the control variable representing firm size and its interactions with supplier coordination and customer coordination are entered in sequence (see Models 2 and 3 respectively). This allows us to study the contingency effects of firm size which may moderate the effectiveness of a plant's supplier and customer coordination programs as hypothesized earlier. Similarly, the control variable representing clockspeed and its interactions with supplier coordination and customer coordination are entered in sequence (see Models 4 and 5 respectively). In all regression model analyses, the variance inflation factors were found to be close to 1 (less than 1.5), thus indicating that multicollinearity among independent and control variables was not a problem.

As can be seen in Model 2 of Table 4, supplier coordination displayed a significant influence on flexibility performance, thus providing support for H₁. Similarly, Model 2 of Table 5 showed that supplier coordination is significantly related to quality performance providing strong support for H₅. Taken together, these results empirically demonstrate the importance of supplier coordination in predicting flexibility performance and quality performance.

As regards customer coordination, Model 2 of Table 4 showed a moderate effect on flexibility performance, thus providing support for H₂. Similarly, Model 2 of Table 5 showed that customer coordination is significantly related to quality performance providing strong support for H₆. As similarly mentioned above, these results empirically demonstrate the importance of customer coordination in predicting flexibility performance and quality performance.

In Models 3 and 5 of Table 4, we examined the moderating effect of firm size and clockspeed by adding the corresponding interaction terms. The additions of interaction terms were significant overall as the increase in R-square over Model 2, respectively Model 4 was statistically significant (F-value). However, the individual parameter estimates were not statistically significant. We interpreted this highly conservatively to indicate lack of support for H_{3a}, H_{4a}, H_{3b}, and H_{4b}. That is, firm size and clockspeed do not appear to fully moderate the effect of supplier coordination and customer coordination on flexibility performance. However, a detailed evaluation of individual effects shows a clearer picture.

Hypothesis H_{3a} stated that the interaction of supplier coordination and firm size was positively related to flexibility performance. As can be seen from the beta coefficient (Model 3, Table 4), this hypothesis was not supported. However, hypothesis H_{4a}, which stated that the interaction of customer coordination and firm size was positively related to flexibility performance, was not supported in terms of directionality (moderately statistically significant but in the opposite direction). Also, H_{3b} stated that the interaction between supplier coordination and clockspeed was positively related to flexibility performance. The corresponding beta coefficient indicated strong support for this hypothesis. However, H_{4b}, according to which the interaction between customer coordination and clockspeed was positively related to flexibility performance, was not supported.

With regards to Table 5, in Models 3 and 5 we examined the moderating effect of firm size and clockspeed by adding the corresponding interaction terms. Again, using the F-value of increase in R^2 , the additions of interaction terms were significant. The statistical significance of increases in R-square over Model 2, respectively Model 4, could have provided broad support for H_{7a} , H_{8a} , H_{7b} , and H_{8b} . However similar to the previous case, the individual effects were not significant indicating that firm size and clockspeed do not fully moderate the effect of supplier coordination and customer coordination on quality performance. However, a clearer picture is detailed by the evaluation of individual effects.

Hypothesis H_{7a} stated that the interaction of supplier coordination and firm size was positively related to quality performance. As can be seen from the beta coefficient (Model 3, Table 5), this hypothesis was not supported in terms of directionality (moderately statistically significant but in the opposite direction). Similarly, hypothesis H_{8a} , which stated that the interaction of customer coordination and firm size was positively related to quality performance, was not supported. Also, H_{7b} and H_{8b} stated that the interactions between supplier coordination, respectively customer coordination, and clockspeed were positively related to quality performance. As can be seen from beta coefficients, both hypotheses were not supported.

7. Discussion

In this paper, we investigated the effects of two types of coordination on the plant performance in the Chinese context. More specifically, we examined the effects of supplier coordination and customer coordination on two dimensions of performance, e.g. flexibility and quality. Our results confirmed the positive impact of supplier coordination on flexibility performance found by Devaraj *et al.* (2007). That is, supplier coordination enhances a firm's ability to handle nonstandard orders that impact the manufacturing process, especially when the demand is increasing. Our results show that supplier coordination influences quality performance, thus

confirming previous studies (Devaraj *et al.* 2007, Koufteros *et al.* 2005). This is particularly important for Chinese manufacturers, taking into account the harsh criticism with respect to the recent recalls of products made in China.

Whereas Koufteros *et al.*' study (2005) indicated that customer coordination has an indirect impact on quality through the effects on product innovation, our study demonstrates a direct impact on quality performance. Similarly, as predicted, customer coordination was found to influence flexibility performance. The collaboration between a firm and its customer reduces production uncertainty, making the firm more responsive to customer demands. Thus, our most important contribution in this study is that both forms of coordination, i.e, supplier coordination and customer coordination are positively and significantly important affecting both quality and flexibility performance. This is also consistent with Fisher (1997) work that both forms of coordination typify different supply chain configurations. The positive effect on quality performance is typical of a functional supply chain, whereas the positive effects on flexibility performance are typical of a responsive supply chain. The fact that these relationships held true in China represents the second most important contribution of this research. Although, Fisher's (1997) and subsequent research on functional and innovative supply chains were largely restricted to the North American context, our study confirms that coordination upstream and downstream are indeed important in the Chinese contexts as well.

Another research objective was to verify if the relationships between the two types of coordination and the two dimensions of performance were contingent upon firm size or clockspeed. In other words, do large firms have an advantage in better leveraging coordination mechanisms on performance. The interaction between supplier coordination and size was directly and positively related to quality performance. This suggests that for large Chinese manufacturers, effective supplier coordination mechanisms pays off via good quality

performance. However, the same is not true for an influence on flexibility performance. Interestingly, the interaction between customer coordination and size was directly and negatively related to flexibility performance. This suggests that in small Chinese firms, deployment of customer coordination mechanisms enhances flexibility performance. This makes sense as companies that are small and desirous of occupying niche segments should integrate well with customer requirements in order to compete with corresponding large-sized competitors. The arena for such a competition may not be in quality performance which is expected but with respect to flexibility performance thereby creating a niche advantage.

The results with respect to the contingency influence of clockspeed was also interesting. The interaction between supplier coordination and clockspeed was directly and positively related to only flexibility performance but not quality performance. Our results suggest that clockspeed strongly altered the effect of supplier coordination on flexibility performance. This suggests that a manufacturing firm may be more able to improve flexibility performance through supplier coordination under a higher clockspeed than under a low clockspeed. This makes sense since the more responsive its suppliers are, the more flexible the manufacturing firm itself is in fulfilling its customers' demands. Customer coordination appears to be equally important in high and low clockspeed firms. Our results also did not indicate moderating effects for clockspeed on either the relationship between supplier coordination and quality performance, or the relationships between customer coordination and flexibility performance.

It is interesting to note that as a post hoc analysis, we examined whether the two types of coordination of supplier coordination and customer coordination had a combined and joint influence on both quality and flexibility performance (Table 6 and Table 7). The interaction effects of supplier coordination and customer coordination was not statistically significant on either the quality or flexibility performance. This suggests that the type and form of coordination

in the upstream supplier side is different from the type and form of coordination on the downstream customer side. Together, they do not explain any additional variance over and above their main effects on performance.

Insert Tables 6 and 7 about here

7.1. Academic Contributions

In summary, our results indicate strong main effects of coordination on performance as well as some interesting contingency effects of size and clockspeed on the coordination-performance relationships. Although, the body of knowledge on supply chain coordination with respect to China is only now emerging, it is interesting to report that our study was one of the first to report strong empirical support for the effective use of supplier and customer coordination influencing quality performance (which is crucial in functional supply chains) and influencing flexibility performance (which is critical in responsive supply chains). In both these types of supply chains, it is not only important to have effective supply chain coordination upstream (supplier) but it is also important to have effective supply chain coordination downstream (customer). Of the two contingency variables, size displayed a more detailed pattern in the coordination-performance relationships as compared to clockspeed.

7.2. Managerial Contributions

Our research has important implications for global supply chain managers, especially those who have interests in the context of Chinese manufacturing sector. For firms that are starting off, they may benefit from the global nature of our findings in that both forms of coordination mechanisms are equally important. These managers can use our items constituting

supplier coordination and customer coordination as an audit tool to gauge where their respective firms with respect to those initiatives. For firms that are further along and would like to benchmark other firms on size or clockspeed, our contingency results may be useful. It appears that our size effects are more robust, thereby facilitating external benchmarking of similar firms (if the focal firm and benchmarking firm are large) or of different firms (if the focal firm is small and the benchmark firm is large and vice versa). With respect to clockspeed our results are less robust as we only found one statistically significant interaction effect.

8. Conclusions

This research contributed to the academic literature of coordination and contingency theories in the emerging economy of China. Specifically, we highlighted the importance of both forms of coordination, supplier and customer, for both types of supply chains, functional and innovative, and in the context of China. Our research also offered fine grained analyses along the contextual condition of large versus small size firms as well as along the contextual condition of fast versus slow clockspeed firms. We also made several significant managerial recommendations to firms desirous of integrating global supply chains that extend to (or start in) China.

Our research is not without limitations. As ours is one of the earliest studies to examine contingency issues pertaining to the coordination-performance relationships in China, it is not surprising that we did not find a consistent set of results with respect to size and even less with respect to clockspeed. Future research can tackle these issues on a more comprehensive basis. Also, we were limited in our items that we could include to capture coordination mechanisms as empirical data collection in China continues to be a challenge. More specifically, we use perceptual data as opposed to the more desirable objective data. Nevertheless, we do not believe that this subjectivity is a cause of unreliability in the interpretation of our results.

Our research can be extended in several ways. Other emerging economies such as Brazil, India and Russia can be used as the context in which the coordination-performance relationships are examined. Newer contextual variables such as experience of the firm, product type and environmental complexity can be examined. Other multidimensional aspects of coordination such as information technology coordination or technology coordination can be separately examined. Attempts can also be made to obtain externally generated objective data to obviate the common method variance problem.

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Table 1a. Literature review - supplier coordination

Key contingency study	Contingency/control variable	Unit of analysis	Finding
Ragatz <i>et al.</i> (2002)	Technology uncertainty	NPD project	Technology uncertainty has a negative impact on cost results.
Petersen <i>et al.</i> (2003)	Technology uncertainty	NPD project	Technology uncertainty is negatively associated with project performance goals.
Petersen <i>et al.</i> (2005)	Stage of integration and supplier's level of responsibility	NPD project	Relationship between project team effectiveness and design quality is stronger in the case of earlier supplier involvement. Project team effectiveness is positively associated with design and financial performance, regardless of supplier's level of responsibility.
Koufteros <i>et al.</i> (2005)	Uncertainty, equivocality, platform development strategy	Plant	Supplier product integration improves quality in high equivocality environments. Supplier process integration improves product innovation capabilities in low equivocality environment.
Lakemond <i>et al.</i> (2006)	Degree of task dependency, degree of diverging expectations, existence of long-term collaboration objectives	Product development project	Not empirically tested

Table 1a (continued). Literature review - supplier coordination

Key contingency study	Contingency/control variable	Unit of analysis	Finding
Koufteros <i>et al.</i> (2007)	Firm size	Plant	Gray-box supplier integration has a positive effect on product innovation, regardless of firm size.
Devaraj <i>et al.</i> (2007)	Firm size, industry type	Plant	There is an indirect relationship between eBusiness technologies and supplier integration that leads to better cost, quality, flexibility, and delivery performance.
Van Echtelt <i>et al.</i> ((2007)	Firm size, environmental uncertainty	NPD project	The need for strategic management processes of supplier involvement is higher for large firms or under uncertain technological/market conditions.
Parker <i>et al.</i> (2008)	Technological newness, buyer-supplier relationship, strategic importance of the supplied item	NPD project	The extent of integration influences project performance when timely tight integration of allied strategic suppliers provides new technologies.
Jayaram (2008)	Firm size, market stability	NPD project	Supplier integration affects performance (product cost, conformance quality, design quality, and time-to-market) under market stability conditions.

Table 1b. Literature review - customer coordination

Key contingency study	Contingency/control variable	Unit of analysis	Finding
<i>Souder et al. (1998)</i>	Technical uncertainty, market uncertainty	NPD project	R&D/customer integration has an impact on cycle time, R&D technical effectiveness, and R&D commercialization effectiveness. Both technical and market uncertainty have a moderating effect on design change frequency; market uncertainty moderates market forecast accuracy.
<i>Koufteros et al. (2005)</i>	Uncertainty, equivocality, platform development strategy	Plant	Customer integration has an indirect impact on quality through the effects on product innovation, especially in high equivocality environments.
<i>Devaraj et al. (2007)</i>	Firm size, industry type	Plant	Customer integration by itself does not directly affect operational performance.

Table 2. Descriptive statistics of item variables

Item	Mean	SD
We frequently are in close contact with our customers	6.09	1.11
Our customers OFTEN visit our plant	4.72	1.88
Our customers give us feedback on quality and delivery performance	5.60	1.24
We strive to establish long-term relationships with suppliers	5.67	1.24
Quality is our number one criterion in selecting suppliers	6.05	1.20
We rely on a small number of high-quality suppliers	4.66	1.56
Product flexibility	4.64	1.66
Volume flexibility	5.12	1.48
Process flexibility	4.37	1.61
Product reliability	5.94	1.08
Product durability	5.86	1.13
Quality (conformance to specifications)	5.90	1.02

Note: All variables are standardized with the mean and standard deviation.

Table 3. Correlation matrix of item variables

Item	Name	B1_1	B1_2R	B1_3	B2_1	B2_3	B2_4	C1	C2	C3	C9	C10
We frequently are in close contact with our customers	B1_1											
Our customers OFTEN visit our plant	B1_2R	0.35										
Our customers give us feedback on quality and delivery performance	B1_3	0.47	0.26									
We strive to establish long-term relationships with suppliers	B2_1	0.31	0.07	0.30								
Quality is our number one criterion in selecting suppliers	B2_3	0.28	0.03	0.23	0.81							
We rely on a small number of high-quality suppliers	B2_4	0.21	0.00	0.12	0.37	0.39						
Product flexibility	C1	0.19	0.14	0.10	0.18	0.13	0.13					
Volume flexibility	C2	0.05	0.04	0.10	0.16	0.13	0.03	0.48				
Process flexibility	C3	0.11	0.13	0.04	0.16	0.12	0.21	0.58	0.34			
Product reliability	C9	0.29	0.15	0.27	0.25	0.19	0.08	0.12	0.10	0.08		
Product durability	C10	0.39	0.17	0.31	0.23	0.19	0.09	0.26	0.12	0.11	0.72	
Quality (conformance to specifications)	C11	0.27	0.10	0.26	0.24	0.23	0.15	0.14	0.14	0.10	0.77	0.71

Notes: All variables are standardized with the mean and standard deviation.
 Cronbach's alpha for the two coordination measures: 0.7671 (supplier coordination) and 0.6242 (customer coordination).

Table 4. Regression analysis of coordination on flexibility performance

Variables	Model 1		Model 2		Model 3		Model 4		Model 5	
	Beta-Coeff	t-value	Beta-Coeff	t-value	Beta-Coeff	t-value	Beta-Coeff	t-value	Beta-Coeff	t-value
Control										
LogSales			-0.09037	-1.59	-0.10666	-1.79***				
LogClockspeed							-0.15320	-2.71*	-0.14465	-2.50**
Independent										
Supplier coordination	0.16779	2.38**	0.16096	2.28**	0.15083	2.13**	0.15660	2.25**	0.16657	2.40**
Customer coordination	0.11979	1.55	0.14236	1.82***	0.15986	2.02**	0.16695	2.14**	0.18770	2.41**
Interactions										
LogSales X Supplier coordination					0.03102	0.34				
LogSales X Customer coordination					-0.12640	-1.75***				
LogClockspeed X Supplier coordination									0.18872	2.35**
LogClockspeed X Customer coordination									-0.06168	-0.81
R ²	0.0532		0.0655		0.0805		0.0879		0.1135	
F-value of R ²	5.45*		4.51*		3.34*		6.20*		4.89*	
ΔR^2					0.02				0.0256	

*p<0.01; **p<0.05; ***p<0.10

Table 5. Regression analysis of coordination on quality performance

Variables	Model 1		Model 2		Model 3		Model 4		Model 5	
	Beta-Coeff	t-value	Beta-Coeff	t-value	Beta-Coeff	t-value	Beta-Coeff	t-value	Beta-Coeff	t-value
Control										
LogSales			0.09740	1.61	0.12362	1.95	-0.00326	-0.05		
LogClockspeed									-0.02374	-0.38
Independent										
Supplier coordination	0.17120	2.27**	0.17855	2.37**	0.16717	2.21**	0.17096	2.26**	0.18901	2.48**
Customer coordination	0.36699	4.45*	0.34267	4.10*	0.32745	3.87*	0.36800	4.34*	0.36939	4.34*
Interactions										
LogSales X Supplier coordination					-0.16240	-1.66***				
LogSales X Customer coordination					-0.00419	-0.05				
LogClockspeed X Supplier coordination									0.07823	0.89
LogClockspeed X Customer coordination									0.10107	1.21
R ²	0.1453		0.1566		0.1702		0.1454		0.1607	
F-value of R ²	16.50*		11.95*		7.84*		10.94*		7.31*	
ΔR ²					0.01				0.0153	

*p<0.01; **p<0.05; ***p<0.10

Table 6. PostHoc regression analysis - flexibility performance

Variables	Model 1		Model 2	
	Beta-Coeff	t-value	Beta-Coeff	t-value
Control				
LogSales	-0.10453	-1.75***		
LogClockspeed			-0.14448	-2.49**
Independent				
Supplier coordination	0.15656	2.20**	0.16757	2.39**
Customer coordination	0.17297	2.11**	0.19044	2.37**
Interactions				
LogSales X Supplier coordination	0.02501	0.27		
LogSales X Customer coordination	-0.12051	-1.65		
LogClockspeed X Supplier coordination			0.18535	2.20**
LogClockspeed X Customer coordination			-0.06102	-0.79
Supplier coordination X Customer coordination	0.05338	0.65	0.01162	0.14
R ²	0.0825		0.1136	
F-value of R ²	2.85**		4.06*	

*p<0.01; **p<0.05; ***p<0.10

Table 7. PostHoc regression analysis - quality performance

Variables	Model 1		Model 2	
	Beta-Coeff	t-value	Beta-Coeff	t-value
Control				
LogSales	0.12628	1.98**		
LogClockspeed			-0.02333	-0.37
Independent				
Supplier coordination	0.17434	2.29**	0.19132	2.50**
Customer coordination	0.34383	3.94*	0.37577	4.27*
Interactions				
LogSales X Supplier coordination	-0.16992	-1.73***		
LogSales X Customer coordination	0.00318	0.04		
LogClockspeed X Supplier coordination			0.07039	0.76
LogClockspeed X Customer coordination			0.10261	1.22
Supplier coordination X Customer coordination	0.06672	0.76	0.02705	0.30
R ²	0.1728		0.1611	
F-value of R ²	6.61*		6.08*	

*p<0.01; **p<0.05; ***p<0.10

Figure 1: Hypothesized model



